engineering proceedings

MDPI

Proceeding Paper

Research on The Design of Prefabricated Industrial Park in Zhengzhou based on The Concept of "Interest-based Relationships"

Yilin Wang[1], Meiwei Wu [2,*]

[1] Nanjing Tech University, Nanjing, China; 201921114097@njtech.edu.cn
[2] Zhengzhou University, Zhengzhou, China.
* Correspondence: anastasiawu@stu.zzu.edu.cn; Tel.: +86 15532022896
† Presented at the 1st International Online Conference on Buildings, 24–26 October 2023; Available online: https://iocbd2023.sciforum.net/.

Abstract: The traditional construction model of industrial parks falls short in meeting the fast-paced demands of economic and technological development. Prefabricated construction, an emerging building technology, offers speed, flexibility, and sustainability, gradually gaining traction in industrial park development. This study focuses on the application of prefabricated construction in Zhengzhou Industrial Park, incorporating the "Interest-based" concept and work-residence relationship orientation. The research aims to propose a replicable and innovative prefabricated industrial park model, serving as a reference for optimizing and updating industrial parks to meet modern needs.

Keywords: prefabricated construction; interest-based; live-work integration; industrial park development

1. Introduction

Industrial parks can play a significant role in attracting foreign investment, driving innovation, solving employment problems, and stimulating local economies. [1] To foster agglomeration economies and enhance local economic development, the government of China has created thousands of industrial parks, which account for a substantial share of the economy. [2] Nevertheless, with the progression of China's economy and the metamorphosis of the construction sector, the conventional development paradigm of industrial parks confronts escalating challenges in today's fiercely competitive park environment. There are various types of industrial parks, but most of them have the characteristics of centralized layout, single function, and spatial isolation, which leads to the problems of incomplete internal functions and the separation of urban and industrial development. [3] Specifically, this model exposes several deficiencies, including industrial convergence, suboptimal land development efficiency, impediments to the establishment of industrial value chains and a relatively low degree of mechanization. [4] Moreover, planning and research efforts haven't kept pace with industrial park expansion, making traditional approaches outdated for modern needs. Thus, there's a need to optimize the construction model for industrial parks.

In recent years, modular construction has gained attention in the construction industry due to its advantages over traditional methods, including: faster and safer construction processes, better predictability to completion time, superior quality, less workers on site, less resource wastage, and less sensitivity to the environment. [5] Prefabricated construction aligns with the industrial park model and offers standardized design and fac-

Citation: Wang, Y.; Wu, M. Research on The Design of Prefabricated Industrial Park in Zhengzhou based on The Concept of "Interest-based Relationships". *Eng. Proc.* **2023**, *volume number*, x. https://doi.org/10.3390/xxxxx

Academic Editor(s): Name

Published: 14 November 2023

tory-based production of components. This study focuses on the applicability of prefabricated construction in Zhengzhou's industrial park development, aiming to assess the practicality of modular design and contribute insights for the evolution of prefabricated industrial parks.

2. Research Background

2.1. Introduction to Zhengzhou's Industrial Parks

Currently, Zhengzhou boasts a diverse array of industrial parks, encompassing 17 major categories, including logistics, IT, e-commerce and cultural creativity, among others. Based on the research from literature and on-site investigations, it is evident that Zhengzhou's industrial parks generally suffer from a lackluster development and relatively low business occupancy rates. Furthermore, the rampant construction of industrial parks in Zhengzhou has led to repercussions, with unauthorized changes in land use frequently occurring. The existing construction and utilization models of industrial parks urgently require updating and optimization.

2.2. Study on the "Interest-based" Concept-Oriented Work-Residence Relationship

In the modern era, "commuting difficulty" is a common urban challenge that affects people's well-being due to the disconnect between work and home. With the Internet's widespread use, online work is becoming the norm, leading to the rise of the SOHO (Small Office/Home Office) culture. Compared to the traditional work-residence separation, the integrated work-residence model offers unparalleled freedom. It's able to use the time otherwise spent commuting to be more productive, or spend it with family and on leisure activities. [6] The development of an integrated work-residence approach can reduce lengthy commuting times and effectively address urban efficiency and commuting issues. "Integrated work-residence" here refers to the spatial relationship between workplaces and homes in a given area.

Social networking has become a valuable platform for young individuals to cultivate interests, connect with like-minded peers, and engage in emotional exchanges. Interest-based communities, often referred to as "tribes," are collective emotional hubs that have gained prominence in today's society. Young people build connections based on shared interests, and these connections can potentially evolve into professional pursuits.

2.3. Study on the Applicability of Prefabricated Technology in Industrial Parks

Traditional industrial parks primarily comprise factory buildings with relatively simple structures, making them compatible with prefabricated construction's characteristics. Modular construction, a novel industrialized building approach within prefabricated construction, represents its ultimate goal. Modular construction exhibits significant advantages in terms of faster and safer construction processes, less resource wastage, and less sensitivity to the environment. [7] Additionally, saving on-site construction labors, increasing on-site construction quality and efficiency make it well-suited for the modern development trend in construction. [8]

3. The Research Process of Industrial Park Modular Design: A Case Study of Zhengzhou Accelerator Industrial Park

The "Design code for residential buildings" (GB 50096-2011) specifies that residential facilities are designed per household, while apartments follow a per-building or per-complex basis. The minimum usable area for various unit types is 30 square meters and 22 square meters (for units combining living and sleeping spaces), respectively. Considering this and the integrated work and living concept, three residential forms are proposed: office apartments, youth apartments, and 2-4 person residences.

Furthermore, according to the "Standard for modular coordination of residential buildings" (GBJ100-87), residential building bays commonly use parameters like 2700mm,

3000mm, and 3300mm, with 300mm as the minimum modular unit for expansion in both bay width and depth. This article selects the existing modular unit of 9000mm x 9000mm in Zhengzhou Accelerator Industrial Park as the spatial module for integrated modular design.

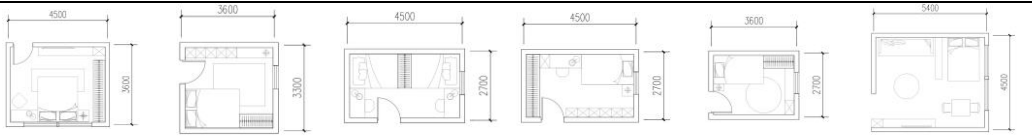
3.1. Basic Functional Module

According to the "Design code for residential buildings" (GB 50096-2011), residential spaces must include at least the basic functional areas, such as bedrooms, living rooms (or halls), kitchens, and bathrooms. Additionally, bedrooms and living rooms can be combined for dual-use, referred to as a combined bedroom and living room.

3.1.1. Bedroom

A bedroom is a space designed for occupants to sleep and rest. In the integrated work and living model, the bedroom configurations in a residential unit can be categorized as follows: one master bedroom and one secondary bedroom suitable for a family, one double room suitable for a couple, two single rooms suitable for co-founders or entrepreneurs, and a single room suitable for a single occupant, which combines the living and sleeping functions. (Table 1)

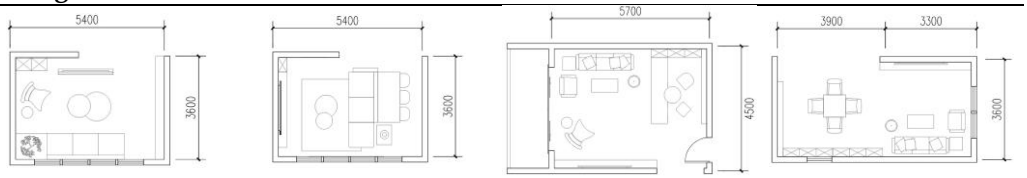
Table 1. Bedroom module.

Double room	Twin room	Single room	Combined room
			

3.1.2. Living Room

The living room is a space designed for residents to gather, entertain, and engage in various activities. In smaller living spaces, the living room can also serve as a bedroom or dining area. In mixed-use residential layouts, the living room may double as an office space. Additionally, it is essential for the living room to have a favorable orientation and an area not less than 10 square meters. (Table 2)

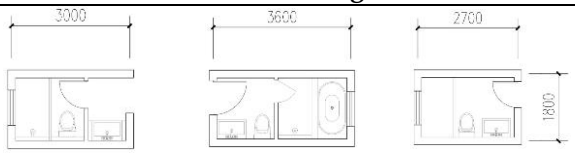
Table 2. Living room module.

Single function	Multi-function	Multi-function
		

3.1.3. Bathroom

The bathroom is an indispensable place in our daily lives, used for personal hygiene, toileting, and bathing, among other purposes. A typical bathroom usually includes a toilet, a washbasin, shower facilities, and a mirror, among other amenities. Also, it requires regular cleaning and disinfection while maintaining good ventilation. In spaces with a larger number of occupants, separate restrooms are provided for males and females. (Table 3)

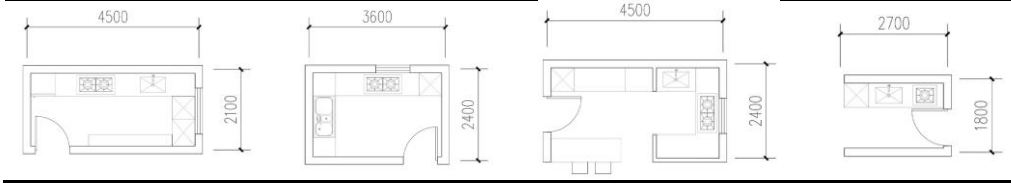
Table 3. Bathroom module.

Attached to the living module			Attached to the office module	
				

3.1.4. Kitchen

The kitchen is the place where we prepare food and dine. A typical kitchen usually includes facilities such as a stove, oven, sink, refrigerator, and storage cabinets. In the kitchen, hygiene and safety are equally important, so regular cleaning and disinfection are necessary. Additionally, kitchens need to have good ventilation to remove smoke and heat. (Table 4)

Table 4. Kitchen module.

Kitchen module


3.1.5. Office

The office is the place where we work and study. A typical office usually includes facilities such as desks, chairs, file cabinets, bookshelves, and computers. In the office, it's important to maintain a quiet and comfortable environment for work and study. Additionally, for the sake of employee health and comfort, good ventilation is essential in the office. In the integrated work and living spaces, in addition to the common individual offices, there are also office spaces that can be used for both work and living.

3.2. Functional Module Combinations

Based on the selected 9000mm x 9000mm module and after simulating lighting and ventilation, the above-mentioned functional modules are combined into residential modules, mixed modules, and office modules.

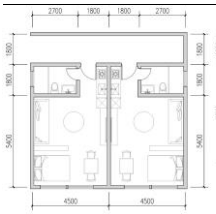
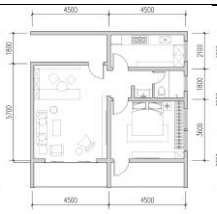
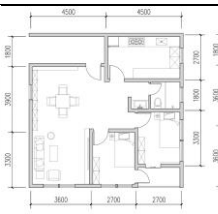
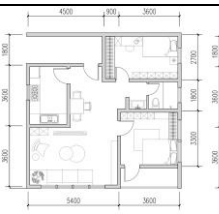
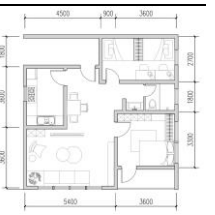
Residential modules are divided into single-person living units, which include single-person apartments with combined living and bedroom spaces, and double-person living units, which further include two single bedrooms or one double bedroom with two different layout options, as well as family living units with two bedrooms and two living rooms, totaling four different layout options. Mixed modules are categorized into half-floor, single-floor, and double-floor layouts based on the company's varying scale requirements. Office modules are divided into single-room, half-floor, and full-floor layouts based on different office space size requirements.

3.2.1. Residential Module

Residential modules are primarily designed for individuals who wish to separate their workspace from their living space. For solo entrepreneurs, a layout with a combined living and bedroom space is sufficient for their daily living needs (Table 5, Layout 1). Single-person living units have smaller demands for the kitchen and lower bathroom usage frequency. For couples or entrepreneurial partners, a larger bedroom space capable of accommodating a double bed is needed (Table 5, Layout 2).For close-knit entrepreneurial partners who share a strong personal connection and wish to reside in the same unit, the space requires two single bedrooms and larger kitchen and bathroom areas (Table 5, Layout 3).For entrepreneurial partners with children, considering the child's resting space, a

relatively larger master bedroom is necessary, along with an additional secondary bedroom (Table 5, Layout 4 and 5).

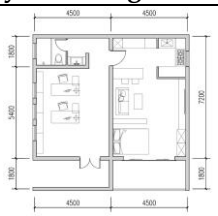
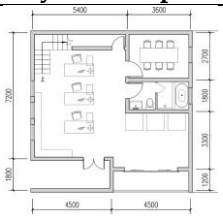
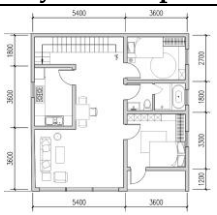
Table 5. Residential module layout.

Layout1: Single room	Layout2: Two-bedroom room	Layout3: Two-bedroom room	Layout4: Two-bedroom room	Layout5: Two-bedroom room
				

3.2.2. Mixed Module

Mixed modules are designed to cater to the needs of individuals seeking a combination of work and living spaces. For cases with a smaller number of office occupants, a single-floor space is sufficient to accommodate both office and residential functions (Table 6, Layout 1). When there are more office occupants, a duplex layout can be utilized, with the first floor serving as the office area and the second floor designated for residential use (Table 6, Layout 2).

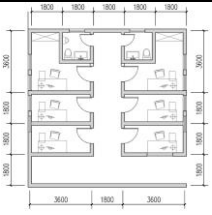
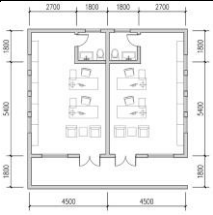
Table 6. Mixed module layout.

Layout1: Single-storey	Layout2: Duplex	Layout3: Duplex
		

3.2.3. Office Module

Office modules primarily provide office functionalities and are situated near the residential modules to meet people's need for a work-life balance. For individuals with a strong preference for self-employed work, single-person office spaces are offered, with shared bathrooms on the entire floor (Table 7, Layout 1).For small-scale studios or companies, there is a need for relatively independent and complete office spaces (Table 7, Layout 2).For slightly larger office setups, additional spaces are required, including meeting rooms, reception areas, and gender-specific bathrooms, among other functional areas (Table 7, Layout 3).

Table 7. Office module layout.

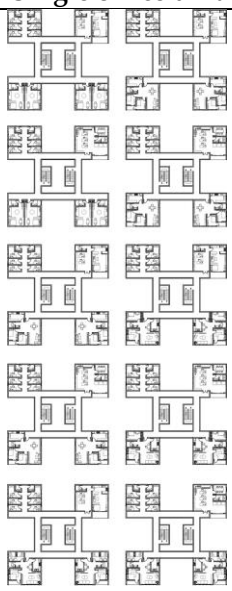
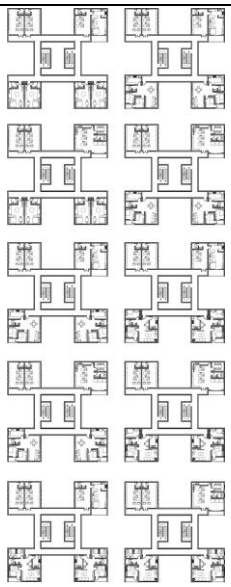
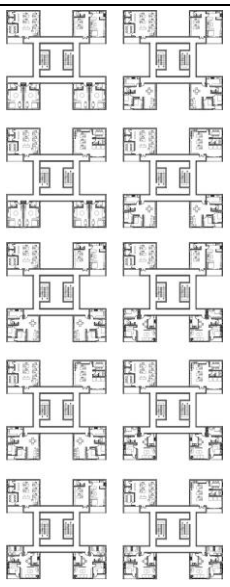
Layout1: Single office	Layout2: Half-floor office	Layout3: Full-floor office
		

3.3. Basic Units

Three functional modules are combined based on specific circumstances to create units of different types tailored to the diverse needs of different populations. For companies of varying sizes, different office and residential modules are arranged and combined according to distinct organizational requirements, resulting in a variety of unit combinations.

Units with inadequate natural lighting and where the number of office workers doesn't match residents within a module have been excluded (Table 8).

Table 8. Unit floor plan summary.

Single office unit	Half-floor office unit	Full-floor office unit
		

3.4. Basic Cluster

Four basic units are arranged to form a basic cluster, creating an open courtyard space at the cluster's center. Connections between cluster levels are established through corridors, which serve as spaces for entrepreneurs from similar industries to engage in communication and discussions.

Interest-based clustering, centered around a particular industry, extends to related industries and continues to grow with related industries at the core. Through this approach, it enhances communication and vitality among various industries. Taking the design industry as an example, it encompasses fields like fashion design and product design. These industries involve the realms of creativity and design, attracting those related to fashion and aesthetics.

3.5. Modular Research

3.5.1. Extraction

This article primarily investigates the first three types of integrated work and living, categorized into two spatial organization models: Separated Work and Living Spaces, catering to shared and commuter integrated work and living, and Combined Work and Living Spaces, serving individuals seeking closer integration. Four modular types are identified: Residential Module (residential functionality), Office Module (office functionality), Mixed Module (combined work and living spaces).

3.5.2. Combination

According to the Industry Standard of the People's Republic of China “Standard for design of office building” (JGJ/T 67-2019), the average per-person office space should not

be less than 6 square meters. As of 2022, the average per-person residential space in China has reached 41.76 square meters, resulting in a proportion of approximately 1:7 between office and residential spaces.

Following the "Interest-Based" work-live concept, units include courtyard spaces. Four modules are arranged in a "field" pattern, and a sunlight analysis is done. As per Zhengzhou's construction regulations, residential building spacing should provide at least 2 hours of sunlight on the coldest day. Sunlight analysis reveals that south and north-east-facing modules meet this requirement and are suitable for residential use. In contrast, northwest-facing modules receive around 5 hours of sunlight on their south side and just 1 hour on their east side, indicating poor sunlight conditions. Thus, office modules are located here.

3.5.3. Connectivity

Within the unit level, various modules are connected through corridors to facilitate communication between different blocks. This well-defined hierarchical spatial arrangement creates favorable conditions for the penetration of courtyard spaces into adjacent areas.

Combining the four units into an interest-industry cluster point (Figure 1) forms a cluster. Within the cluster level, connections are established through corridors, and these corridor spaces serve as interest-industry spaces. Taking into account the lighting and ventilation of the four modules, vertical transportation is arranged on the inside of the corridors. When combining units at the cluster level, there are three architectural treatment approaches: intersecting, connecting, and separating (Figure 2). The intersecting approach results in less natural lighting for the inner modules, which does not meet the lighting requirements for residential spaces. Therefore, let's discuss and analyze the connecting and separating approaches below.

Figure 1. Unit module axonometric.

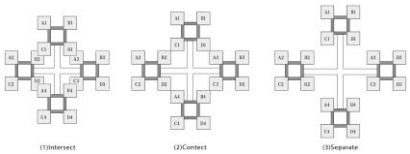


Figure 2. Inter-unit connection.

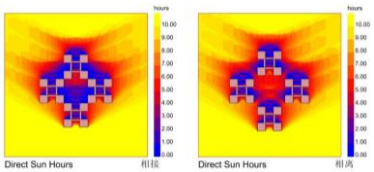


Figure 3. Direct sunlight analysis.

An analysis of the direct sunlight duration during the coldest days of winter in Zhengzhou is conducted for the connecting and separating approaches (Figure 3). The analysis reveals that when the connecting approach is used, there is a significant area with zero sunlight duration, indicating poor lighting conditions. On the other hand, the separating approach provides more suitable lighting conditions. Therefore, the decision is made to adopt the separating arrangement between modules.

3.5.4. Growth

The interest-based growth model facilitates closer cluster connections, expanding as needed. New clusters connect through corridors, forming interest-based industry hubs. Residents can select clusters based on hobbies, but diverse interests require more options. Cluster growth allows residents to engage with various industries.

Similar interests exist in related industries and at corridor intersections, promoting interaction among like-minded individuals. This decentralized cluster approach offers universal insights for constructing other modular industrial parks.

3.6. Limitation

Based on the above explanation, the area of each module in this research design is certain and at an average level. Therefore, when the industrial park is built in this mode, the size of the company will be limited, and larger companies will not be able to work here. It has a certain impact on the economic development of the industrial park.

4. Conclusion

This study explores "Interest-based" connections and innovative work-residence relationships using Zhengzhou Accelerator Industrial Park as a case study. It uses 9000mm * 9000mm as the basic module size and defines three core unit types: residential, office, and mixed modules. These units are combined into diverse clusters. Four units form interest-based industry convergence points, expanding and aggregating between clusters. In addition, it provides detailed designs for basic modules to create a variety of module libraries, allowing designers to select suitable modules from them based on project requirements, thereby accelerating the design process while ensuring flexibility and creativity in design.

This study employs modern modular design and prefabricated construction to create a scalable model, offering guidance for similar projects. Its goal is to promote standardized industrial park production, aiding the construction industry's quality development.

References

1. He, Y.; Zhu, Z.; Xie, H.; Zhang, X.; Sheng, M. A Case Study in China of the Influence Mechanism of Industrial Park Efficiency Using DEA. *Environment, Development and Sustainability* **2023**, *25*, 7261–7280, doi:10.1007/s10668-022-02290-x.
2. Kahn, M.E.; Sun, W.; Wu, J.; Zheng, S. Do Political Connections Help or Hinder Urban Economic Growth? Evidence from 1,400 Industrial Parks in China. *J. Urban Econ.* **2021**, *121*, 103289, doi:10.1016/j.jue.2020.103289.
3. Shi Guang, LI Jianfei, CAO Yi, et al. Application of "Industrial Neighborhood Unit" on Planning of High-tech Industrial Park: A Case Study on Nansha Electronics and Information Industrial Park in Guangzhou. *City Planning Review*，**2013**(5): 42-46.
4. Zhang, M. Research on the Problems Existing in the Construction of Urban Industrial Parks and the Countermeasures. *Management & Technology of SME* **2021**, 146–147.
5. Ferdous, W.; Bai, Y.; Ngo, T.D.; Manalo, A.; Mendis, P. New Advancements, Challenges and Opportunities of Multi-Storey Modular Buildings – A State-of-the-Art Review. *Eng. Struct.* **2019**, *183*, 883–893, doi:10.1016/j.engstruct.2019.01.061.
6. Hensher, D.A.; Beck, M.J.; Wei, E. Working from Home and Its Implications for Strategic Transport Modelling Based on the Early Days of the COVID-19 Pandemic. *Transportation Research Part A: Policy and Practice* **2021**, *148*, 64–78, doi:10.1016/j.tra.2021.03.027.
7. Ferdous, W.; Bai, Y.; Ngo, T.D.; Manalo, A.; Mendis, P. New Advancements, Challenges and Opportunities of Multi-Storey Modular Buildings – A State-of-the-Art Review. *Eng. Struct.* **2019**, *183*, 883–893, doi:10.1016/j.engstruct.2019.01.061.
8. Zhengdao Li, Geoffrey Qiping Shen, Xiaolong Xue, Critical Review of the Research on the Management of Prefabricated Construction, 43 Habitat International, **2014**, pp. 240–249, http://dx.doi.org/10.1016/j.habitatint.2014.04.001.